Assessing Occupational Health and Safety in Facility Planning: A Case Study

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Keywords: occupational health and safety, facility layout design, safety criteria checklist

Abstract

Facility planning considers the design, layout, location and accommodation of people, machines and activities of a system or enterprise within a physical environment. Appropriate decisions on facility layout, concerning the spatial allocation of departments and equipment (e.g. machines) and the required connections among them, can organize the production more efficiently and increase safety. A well-designed facility can ensure that adequate space is assigned for maintenance and operation that unnecessary movements are avoided, and the range of machine movement is considered. In spite of this, safety is not considered extensively in facility planning. Occupational Safety and Health Administration (OSHA) has provided little guidance to assist industries in finding reasonable solutions to the issues raised from safety in the layout design.
In this paper, a case study is carried out to investigate the safety issues in relation to layout design. The case study was conducted at a hospital kitchen in Montreal - Canada, which is being fully renovated. The kitchen contains several hazards and numerous equipment. The principles can be easily transposed to a manufacturing context, involving machines.
The case study validates the list of hazards proposed in previous research and adds additional criteria that need to be considered when designing the facility layout for the kitchen. The hazards in the kitchen are presented and will guide the design of the new layout which will consider safety as one of its main factors. In other words, this research improves the layout design by including safety aspects.

1. Introduction

Millions of workers die, are injured or get sick every year as a result of workspace hazards. It is estimated that at least 250 million occupational accidents occur every year worldwide (Alli, 2001). The suffering in terms of human life from these accidents is enormous, while the economic cost of the failure to ensure occupational health and safety (OHS) is also excessive.
Selecting a good facility layout, which is defined as the physical arrangement and assignment of departments and machines to specific locations on the floor, is a critical decision in facility planning (Roslin, Seang, & Dawal, 2008).
One of the most influential factors affecting the efficiency of a production facility is its layout. A poor layout implies that, regardless of other factors, the facility will be inefficient. The interactions between each pair of departments must be taken into account in order to obtain the most efficient layout. These interactions are the flow of material between departments (Abdinnour-Helm & Hadley, 2000). A measure for efficiency can be based on the total cost of transporting these materials between different departments.
In practice many more factors need to be considered in addition to minimizing the cost involved in movement between departments (Heragu, 2006). As such, one factor is providing a safe environment for personnel.
Unlimited number of hazards can be found in almost any workplace. There are obvious unsafe working conditions, such as unguarded machinery, slippery floors or inadequate fire precautions. There are also a number of categories of insidious hazards, including chemical and physical hazards, psychological hazards, and hazards associated with the non-application of ergonomic principles. When developing a facility layout, designers should consider these hazards.
Furthermore, much attention are being paid to occupational health and safety systems, legal requirements, OHS have become essential, in recent years. A checklist which has been proven to be an efficient tool for safety and risk

assessment is expected to bring a company's voluntary initiative into all areas of workplace and facility OHS promotion (Nishikido et al., 2006). On the other hand, most previous checklists have focused mainly on improving ergonomic work conditions or the workplace environment (Harms-Ringdahl, 2001). Some of the literature on applying checklists as a risk assessment tool is presented in following paragraphs.

(Nishikido et al., 2006) developed a new multi-dimensional action checklist that can support employers and workers in understanding a wide range of OHS activities and to promote participation in OHS in small and medium-sized enterprises. Their checklist was formulated consisting of 6 core areas, 9 technical areas, and 61 essential items.

(Keyserling, Stetson, Silverstein, & Brouwer, 1993) developed a two-page checklist for determining the presence of ergonomic risk factors associated with the development of upper extremity cumulative trauma disorders. This checklist was used by plant personnel at four work sites to assess the presence of risk factors in 335 manufacturing and warehouse jobs.

(Brodie & Wells, 1996) presented a preliminary testing of the reliability and accuracy of three previously developed ergonomics checklists: Rapid Upper Limb Assessment; Occupational Safety and Health Administration draft risk factor checklist; and the Posture and Upper Extremity checklists. The evaluation was carried out in a car manufacturing environment.

(Shikdar & Sawaqed, 2003) identified factors that affected worker productivity and OHS in selected industries in a developing country and among fifty production managers. (Kazutaka, 2002) reviewed the research implications of the new principles of occupational safety and health management systems based on recent developments in Asian countries.

Furthermore, the relationship between facilities layout and occupational safety has not been researched extensively. (Chang & Liang, 2009) developed a model, based on a three level multi-attribute value model approach, in order to evaluate the performance of process safety management systems of paint manufacturing facilities. (Fernandez-Muniz, Montes-Peon, & Vazquez-Ordas, 2007) developed a Safety Measurement System Scale, based on the results of a questionnaire survey of 455 Spanish companies, in order to guide the safety activities of organizations.

The objective of this study is to test the checklist, presented by the same authors in a previous study (Moatari Kazerouni, Agard, & Chinniah, 2012). The same approach presented in that study is used in this paper, which is identifying the risk factors that exist in the facility by going through the items presented in the checklist. Moreover, the safety factors relevant to the layout design of facilities are modified based on a case study implementation. This modified checklist can support facility planners in understanding the value of inclusive array of OHS concerns in facility layout design.

2. Methodology and Information Collection

A case study approach is used in this research in order to assess the OHS in the layout re-design of a hospital kitchen in Montreal – Canada.

This research uses the safety criteria checklist for facility layout planning, introduced in (Moatari Kazerouni et al., 2012). The checklist is used to identify the occupational health and safety issues that are not well-considered in the current design of the kitchen, though essential for its new layout.

The information in relation to the hazardous situations that exist in the current design of the kitchen is gathered via observations and interviewing with the kitchen staff.

Several observation sessions as well as performing them in various working hours of the kitchen have insured the validity of collected information. The items indicated in the checklist were evaluated through these observations and field notes were taken.

Moreover, interviewing with the staff shed light on other safety concerns that exist in the kitchen.

3. Case Study Description

The case study was conducted in the kitchen of a hospital where the food is prepared, stored and distributed to every patient.

The kitchen was originally design in 1907. Over the time, different improvements and modifications were executed although with no global coordination.

Recently, it was decided to renovate the kitchen by changing the facility layout. The main reason for this renovation is the kitchen being old as well as to enhance additional services such as the room service for having specific food requested at different times than the usual food serving meals. The new concept of room service requires important improvements in the distribution and production area. Different equipment had to be renewed and the facility layout had to be modified to cater for the new concept. Therefore, changes

in the layout design of the kitchen seemed necessary and the hospital has decided to update all the food service area.
Since occupational health and safety is one of the important issues to be considered at the hospitals and specifically in the kitchen, this research provided an evaluation of OHS considerations. This case study aimed to investigate the OHS issues regarding every sections and machines in the kitchen.

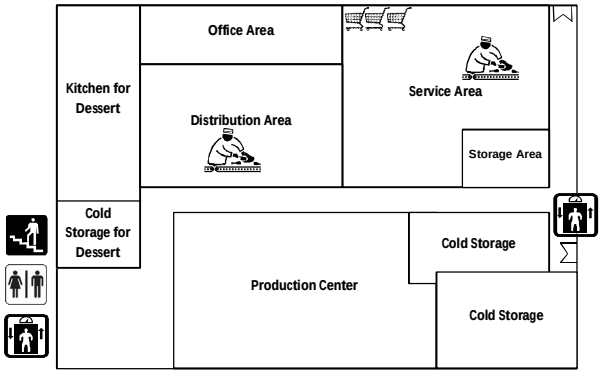

Figure 1 Current layout of the kitchen

A sketch of the current layout of kitchen is illustrated in Figure 1. The kitchen consists of different sections: office area, production area (food preparation), distribution centre including a conveyor and workstations for mounting the food trays for patients, service area for weighing portions and selecting ingredients for recipes, section for pastries, area for washing the trolleys (used for transporting trays), area for dismounting the used trays collected from patients, area for washing the dishes and trays, storage areas i.e. refrigerated rooms for perishables and storage room with racks for non-perishables items.
The workers are not presently trained on safety subjects. No particular training or certification program is offered to the staff working in the kitchen. Few guidelines or safety standards are followed by the kitchen; whereas little safety inspections are carried out. Thus, assessing OHS of the current kitchen design is useful before planning its new layout.

4. Results and Interpretations

The following sections present the initial safety criteria checklist as well as its case study implementation.

1.1 Safety Criteria Checklist

The safety criteria checklist developed by (Moatari Kazerouni et al., 2012) is used in this research. This checklist consists of six major criteria:

Machine safety: this safety factor deals with some of the principals involved in providing safety in oppose to the common hazards caused by machineries and equipment; examples are: placement and distance of machines, machine standardization, storage, safeguards, and material feeding.
Movement: discussions on safety of material handling from the perspective such as load, equipment, gang-way spaces, interruption and unnecessary movements are presented in this safety factor.
Material safety: the type and physical-chemical characteristics of the material used in the manufacturing process are studied in this safety factor.
Workforce and ergonomics: safety of workers is ensured by exercising factors including: their experience, training and education, flexibility of jobs, Contact between workforce and machines, use of personal protective equipment, as well as the ergonomics approaches.
Maintenance and service: accessibility and distances among machines, as well as the maintenance services concerned this safety factor.
Environmental safety: the working environment should provide proper illumination, noise control, ventilation and temperature in order to accommodate the workers. Other environmental hazards could be caused from electricity and released of stored energy, fire and thermal changes, and waste disposal.

The elements of these six safety criteria are used to assess the OHS in the current design of the kitchen.

1.2 OHS Assessment in the Hospital Kitchen

The following paragraphs discuss on studying the safety criteria checklist by means of observations and interviews. The applicable OHS issues are briefly described.

1.2.1 Machine Safety Criteria

Placement of machines

- Each machine has its own power supply and energy isolating devices.
- There is one dish washing machine/conveyor in the kitchen. This cause long queue of trolleys filled with dirty dishes waiting for getting washed.

Standardization of machines

- Use of machines is restricted to the authorized personnel (who can receive little training).

- Proper and safe utilisation of tools according to the manufacturer's instructions is used. The labels and guidance are attached on the machines and equipment about how to use them. Instructions about the buttons and valves of the machines are available; e.g., warning signs or safety precautions for using ovens are available on the machine.

Storage space
- Storage locations for each type of item are planned separately. Liquid and solid materials are kept well separated. Storage spaces for cold and raw material are separate. Products are shelved based on their characteristics (e.g., meat, dairy, vegetables) in the storage refrigerators.
- Incompatible materials are separated. Chemical liquids are stored in a place different from other material while properly labelled.
- Each storage area can contain a certain quantity of material.
- Materials are kept organized in the storage areas. The materials are kept within their boxes or the racks when they are placed on the shelves. Similarly, inside the cold storage area, materials are kept within the trolleys.
- Specific labels are used for the material kept in the storage. Storage drawers as well as all the cabinets are labelled based on their content.
- There seems to be no rule that asks to keep the lighter material on top and heavier material on the lower shelves in the raw material storage area.
- The distance of the material on the top shelf from the ceiling is adequate.
- Storage piles are stable and secured from falling or collapse.

Machine safeguard flexibility
- The vegetable slicer is not properly safeguarded.
- The person working with the meat slicer does not consider every safety issues by just putting his hand on the edge of the cutter.

1.2.2 Movement Safety Criteria

Material handling load
- The loads are properly balanced and secured.
- Workers do not always follow the weight limits for manual lifting, carrying, pushing and pulling. For example, a worker was observed pushing several trolleys at the same time.

Material handling method and equipment
- Manual handling aids are accessible. The wheeled stool is used to carry vessels between machines (e.g., for moving the hot and boiling pots to the oven or the mixer machine). Also ladders are available to reach the material on higher shelves at the storage area.
- Trolleys are numbered and placed in their specific location in the service area.
- Trolleys are sometimes used to carry both cold and warm food. This can cause problem when loading the trailer with for example cold food right after it has been unloaded from the warm food (while tray is still warm).
- Proper lifting techniques are considered; e.g., trolleys are used to move the material, food, and dishes.

Minimum aisle widths
- Sufficient gang-way space for materials is considered; e.g., enough corridor and aisle between the rows at the storage area.
- Sufficient space for the operators around the machines as well as sufficient aisle for the material handling equipment is considered.

More/longer distance unnecessary movements are not always avoided. For instance, the raw materials as well as the dirty dishes are brought back to the kitchen by using the elevator which is located on the side of the kitchen and on opposite to the raw storage and the dish washing conveyor.
Un-safe interruption in material handling may not be avoided. The corridors used for the workers are the same as the ones used for the material handling equipment. This causes interruption in movements as workers may bump into the material handling equipment while it is also dangerous, for example when hot pots are carried.

1.2.3 Material Safety Criteria

Type of product (physical-chemical characteristics): all materials and their containers are labelled.
Information and guidelines about WHMIS (Workplace Hazardous Materials Information System) is posted on the wall.

1.2.4 Workforce & Ergonomics Safety Criteria

Training and education
- Workers are not trained and tested on safety subjects. No particular training or certification program is offered to the staff.
- Workers are experienced.
- Only authorized personnel can enter the kitchen.
- Only authorized personnel work with the machines.

Personal protective equipment

- Approved protective equipment is available; e.g. gloves, special hats, lab coat and apron.
- Protective equipment is used against hazards that cannot be eliminated. The use of special hats and the white lab coats are mandatory. However, wearing cloves is not an obligation in the kitchen.
- Protective equipment, emergency and first aid equipment are easily accessible. They are stored as close as practicable to the point of use and their locations are clearly marked.
- The protective equipment is located right before entering the kitchen, therefore easily recognizable and accessible by the staff.

Job flexibility

- Confusions caused from several operations which carried out simultaneously are avoided.
- A work can have flexible schedule with variable start/end.

Contact between workforce and machines

- Stable work platform suitable for the nature of the work exists. Every machine is grounded and stabilised on its position.
- There is safe access to the machine for operators from every possible corner.

Ergonomic hazards

- Using physical force (lifting heavy objects) is avoided by using trolleys for different movements; e.g., transferring food to the rooms, food/material to the refrigerators and storage spaces, as well as for dishes.
- Duration of the job being over a long period is not an issue in the kitchen.

1.2.5 Environmental Safety Criteria

Lack of illumination

- Illumination is adequate for the normal conditions at the kitchen. However, some of the lights, especially in the distribution area, are not working properly or are out of work.
- The exit lights are properly illuminated.

Noise disturbance

Noise levels are within acceptable limits in the kitchen. However, the dish washing conveyor can be noisy and disturbing for the operators around it. Also the noise caused from the ventilation system can be annoying.

Respiratory hazards

- The ventilation system is employed in the kitchen to control the respiratory hazards. However, it does not work properly. Its flow rate and fan speed are not adequate and the noise level is high. This can be because of the ventilation filter being greasy and smoky since it has not been changed for a long time. Consequently, for example, the steam from the cooking is not absorbed well.
- Improper ventilation by using fans instead of the air conditioning; while fans are placed in front of each other which will not allow the circulation of air.
- Special funnel are used to direct the vapour produced from the dish washing machine to the outside.

Sewage and waste disposal

- There are special paths under the boiling containers for the waste water and liquids. However, some floors of the kitchen are slippery because of the waste water (e.g. floating water near the dish washing machine).
- The elevators used for transporting the sewage and disposals are different from the ones used for delivering food and kitchen material.
- Waste storage areas, e.g. bins and containers, are available. They are kept closed except when adding waste.

Fire and explosion

- Portable fire extinguishers are mounted properly, accessible and inspected. There are signs indicating the location of the fire extinguisher.
- "No Smoking" areas are designated and signs clearly indicate it.
- Smoke and heat detectors are available and functional in every area of the kitchen. Fire alarms are installed in place.
- The guidelines in case of fire (e.g. fire from the oven) are available.

Electricity or released of stored energy

- Cables, plugs and insulation are damaged in some places.
- Machinery and equipment are grounded.
- Electrical panels have clear access and are clearly marked.
- Outlets, switches and boxes have covers.
- There is the permanent wiring in place; no extension cords are used while separate sockets are used to plug in for different machines.
- Emergency stops and critical controls are identified. The emergency stop button is used for the food conveyer, washing machine conveyor, etc.
- Electric boxes are locked, the sign of danger is placed on the box, instructions and warnings are also available on the box.
- Instruction about the voltage that should be used for the machines are available on them.

Emergency and life safety

- Emergency exits are clearly identified and exit signs are available.
- Entry/exit doors are designed in different sides of the kitchen.
- Walkways maintained, aisles defined and uncluttered. Aisles are defined and their limits are marked with yellow-black colours.
- Aisle ways are not free from material storage and debris in every place. There are some boxes and cartons placed unattended.
- There are devices to detect, warn and protect against an impending/existing adverse environmental condition; e.g. speakers are placed in different locations of the kitchen.
- First aid kits are available.

Thermal Changes

- The dish washing machine cause a lot of heat in place and the fans cannot cool down the environment.
- Guidelines about the necessary temperature are available.

Hygiene

- Guidelines and information notes about the hygiene are available (e.g. for cleaning).
- Guidelines and notes about using the material and products (e.g. to always check out the expiration date of products before using them) are available.
- Guidelines for using the products for hand washing and for washing the dishes are available.
- Plan of the hygiene of the kitchen is placed on the wall.
- Hand washing sinks are available in different locations of the kitchen.
- Housekeeping and cleaning tools/material are available.
- Fly-traps are hung from the ceiling in different locations.
- The special hats and lab coats should be worn when being inside the kitchen and special signs indicate its necessity.
- Using gloves is not very common among the employees but also not an obligation at the kitchen.

1.2.6 Infrastructure

Corrosion and cracks

- Corrosion and rusting exist on some of the pipes.
- There exist cracks on the walls and behind the machines.
- Cracks and corrosions exist at the vapour funnel of the dish washing machine.

Facilities locations

- The height of the ceiling in the two sections of the kitchen (distribution and production areas) is different, while the height of the ceiling in some places seems to be inadequate. It can cause problem for example in some storage areas.
- The office areas are well separated from the kitchen and the storage areas.
- The washrooms are located in a separate place from the other parts of the kitchen.
- Plan of the kitchen areas and the machines that are in the kitchen is placed on the wall.
- Different elevators are used for the food, one for the dirty dishes and one for the waste and disposal material.
- There are specific schedules for using the elevators.
- A specific location is assigned to the dirty cloths and gloves.

5. Further Discussion

For this particular case application, the "maintenance and service" safety factor of the checklist was not relevant. The new safety factor of "infrastructure" was discussed. Whereas other safety issues, for example life safety and hygiene, were proposed for being included in the checklist. Therefore, the safety criteria checklist could be modified as presented in Table 1.

The study signified that the "environmental" issues bring up the main safety concerns in the hospital kitchen. The ventilation system requires major repair since it does not work properly. Parts of the lighting system, especially in the distribution area, do not function; therefore need to be changed. Besides, more strict regulations have to be employed for wearing gloves in the kitchen.

Un-safe interruptions in material handling are another safety concern in the kitchen. The absence of a predefined direction for workers and material handling equipment movements lead to this problem, which could be resolved by a better layout design. Similarly, unnecessary movements in the longer distances could be avoided by considering changes in the layout design.

Corrosion and rusting as well as the cracks on the walls require significant consideration. Additionally, the possibility of equalling the height level of the ceiling in the distribution and production areas should be deemed.

Changing the dish washing conveyor to one which can handle more plates could solve the problem of the long queue of dirty dishes' trolleys. However, the cost factor consequences have to be taken into consideration. Otherwise, not

connecting the dirty dishes as they are being removed from the trolleys to the dish washing conveyor could be an option.

Machine	- Placement and distance of machines - Standardization of machines - Degree of automation - Storage space - Machine safe guards flexibility * - Safety in material feeding *
Movement	- Material handling load - Material handling method and equipment - Machine movement - Minimum aisle widths - Safe guarding the material handling equipment * - More/longer distance unnecessary movements * - Un-safe interruption in material handling *
Workforce & Ergonomics	- Training and education - Personal protective equipment * - Job flexibility - Contact between workforce and machines - Ergonomic hazards
Maintenance & Service	- Access to machines for setting, maintenance or repair - Machine safe guard flexibility - Adequate space for critical maintenance and auxiliary services during operation *
Material	- Type of product (physical-chemical characteristics) * - Characteristics of product (e.g. size, shape, volume, weight) - Material safety information and guidelines *
Environmental	- Lack of illumination - Noise disturbance - Respiratory hazards - Sewage and waste disposal * - Fire and explosion - Compressed air and gases * - Electricity or released of stored energy - Emergency and life safety * - Thermal changes - Radiation hazards * - Hygiene *
Infrastructure *	- Corrosion and cracks * - Facilities locations *

* *Newly added safety criteria*

Table 1 modified safety criteria checklist

Furthermore, workers should be given adequate training and be evaluated on the safety subjects. Also the vegetable slicer and meat slicer machines have to be properly safeguarded.

These safety factors need to be considered more precisely in order to be modified for the new design of the kitchen layout. However, in applying the facility planning tools for designing the new layout, not all these factor is already deliberated (e.g. the environmental safety factors). Numerous problems can be avoided in designing or modifying layouts if facilities plans are reviewed for safety aspects before initiating any construction or change. Hence, developing a model which integrates safety factors in facility planning tools is necessary. By this means, safety issues would be considered as an important factor as cost, closeness, material flow, flexibility, or material handling system concerns, in the facility layout problems.

6. Conclusions

Improving worker productivity and occupational health and safety are major concerns of industries. One of the common features of these industries is the improper facility design. This leads to workplace hazards, poor worker health, mechanical equipment injuries and disabilities, which, in turn, would reduce workers' productivity, the work quality and increases the cost. This has effects on the overall performance of a company. It would, therefore, be extremely difficult to attain company objectives without giving proper consideration to OHS concerns when planning the facility layout.

The main objective of this research was to appraise a list of safety criteria which was developed to be considered when planning the initial design or modifications in layout of facilities. Different issues suggested in this list were evaluated and the ones that needed to be considered more precisely were identified in order to be adapted in the new design of the kitchen layout. Hence, the research has validated the list of safety criteria proposed in (Moatari Kazerouni et al., 2012), while investigated its actual implementation through a case study at a hospital kitchen.

The outcomes of this research provide a tool that can help providing a safer working environment for the kitchen staff and which can be applied to other layouts; it identified the various risks in the kitchen and guides the proposal of OHS changes that need to be considered when redesigning the kitchen layout.

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